

B R E V I O R A

Museum of Comparative Zoology



US ISSN 0006-9698

CAMBRIDGE, MASS.

26 MAY 2016

NUMBER 549

DISCOVERY OF A REMARKABLE NEW BOA FROM THE CONCEPTION ISLAND BANK, BAHAMAS

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ABSTRACT. The Bahamas Archipelago is currently known to support three of the 11 recognized species of West Indian boas (genus *Chilabothrus*) on the Little Bahama Bank, Great Bahama Bank, and four of the southern Bahamas banks. Here we report the discovery of a new species occurring on the Conception Island Bank, located 25 km ENE of Long Island and the Great Bahamas Bank. We describe *Chilabothrus argentum* **sp. nov.** (Conception Bank Silver Boa) on the basis of morphometric and genetic data obtained from six individuals. This new boa has a greatly reduced coloration relative to other Bahamian boas, is highly arboreal, and is 3.3% (pairwise) divergent from other West Indian boas in a mitochondrially encoded protein. We estimated a mitochondrial coalescent time of 2.7 million years for this species, and phylogenetic analysis suggests that it is sister to the *C. strigilatus*/*C. striatus*/*C. exsul* clade. The existence of this new boa provides greater resolution of the historical biogeography of the West Indian boas in the Bahamas Archipelago, further supporting multiple colonization of this region from Hispaniola as well as speciation and divergence events dating to the late Pliocene/early Pleistocene. We additionally discuss conservation implications and concerns for this new boa, which we have assessed as being critically endangered on the basis of the International Union for Conservation of Nature Red List criteria and hence find it to be one of the most endangered boid snakes globally.

KEY WORDS: Boidae; Caribbean; *Chilabothrus*; mtDNA; phylogenetics; systematics

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INTRODUCTION

“Subsequent collecting in the Bahamas will yield additional herpetological novelties, and, possibly, even other representatives of *Epicrates*”—Netting and Goin, 1944.

The Bahamas Archipelago has long been touted as a natural laboratory for the study of ecology and evolution (Schoener, 1968; Toft and Schoener, 1983), whereby a large latitudinal footprint, many islands of varying sizes and isolation, and proximity to large

centers of diversity in the Greater Antillean islands combine to produce a rich ground for scientific study. The islands of the Bahamas, though generally low lying (< 60 m above sea level [asl]), exhibit a remarkable diversity of terrestrial and aquatic life (e.g., Correll and Correll, 1982). The region is characterized by hundreds of presently emergent islands developed on carbonate platforms (“banks”) that have been periodically inundated and exposed to varying degrees, yet have remained physically separate from each other (Sealey, 2006). These banks range in size from the Great and Little Bahamas banks (103,000 km² and 14,769 km², respectively) to the Conception Island Bank (16 km²). Some presently inundated banks, such as the Silver, Navidad, and Mouchoir banks, would have closely linked the Lucayan Archipelago to Hispaniola, whereas an emergent Great Bahama Bank would have reached within ~ 17 km of Cuba.

The herpetofauna of the Bahamas represents a mixture of species derived largely from Cuban and Hispaniolan ancestors, as well as some in situ speciation (Knapp *et al.*, 2011). A distinct biogeographic separation is apparent between the Great Bahama Bank and other Bahamas banks, whereby the herpetofauna of the former is relatively undifferentiated from West Indian ancestral lineages and the latter appears to include more ancient colonization and in situ speciation events (Hower and Hedges, 2003; Hedges and Conn, 2012; Reynolds *et al.*, 2013; Geneva *et al.*, 2015). A long history of herpetological exploration has occurred in the region (Franz *et al.*, 1996), stretching back to the notes of Columbus detailing observations of iguanas and sea turtles. Exploration began in earnest with an Academy of Natural Sciences expedition in the 1860s and Samuel Garman of the Museum of Comparative Zoology (MCZ) in the 1880s, followed by the peregrinations of Thomas Barbour, former director of the MCZ, aboard the yacht

Utowana in the early 1930s. Since this time the Bahamian Archipelago has blossomed as a research site for legions of scientists, with significant terrestrial focus on the native herpetofauna (Franz *et al.*, 1996; Knapp *et al.*, 2011). Several active research stations are maintained in the region, and several major research programs are dedicated to the study of Bahamian herpetofauna. With so much research activity, it seems unlikely that a large vertebrate would go unnoticed on even the most remote Bahamian island. Indeed, the Bahama Hutia (*Geocapromys ingrahami*), formerly presumed extinct, was rediscovered on the remote Plana Cays in 1966 (Turvey and Dávalos, 2008).

The West Indian boa genus *Chilabothrus* is represented by 11 presently recognized species, with eight species distributed across the Greater Antilles and three species in the Bahamas Archipelago. Bahamian endemics include the Northern Bahamas Boa (*C. exsul*), the Bahamas Boa (*C. strigilatus*), and the Southern Bahamas Boa (*C. chrysogaster*). The Northern Bahamas Boa is distributed on the eastern Little Bahama Bank, largely on eastern Great Abaco Island and satellites, and possibly on eastern Grand Bahama (Schwartz and Henderson, 1991). The Bahamas Boa is comprised of five subspecies occurring across the Great Bahama Bank (Sheplan and Schwartz, 1974) and was recently elevated from synonymy with the Hispaniolan Boa (*C. striatus*; Reynolds *et al.*, 2013). The Southern Bahamas Boa is a complex of three subspecies occurring on the Turks, Caicos, Inagua, and Crooked-Acklins banks in the southern Bahamas Archipelago (Buden, 1975; Schwartz and Henderson, 1991). The last taxonomic treatments of the West Indian boas, outside of the changing of the genus name from *Epicrates* to *Chilabothrus* (Reynolds *et al.*, 2013), were the elevation of *C. strigilatus* from *C. striatus* (Reynolds *et al.*, 2013) and the elevation of *C. granti* from *C. monensis* (Reynolds *et al.*,

2015; Rodrigucz-Robles *et al.*, 2015), all of which were based on known populations and specimens and involved the application of genetic analyses to uncover substantial evolutionary divergence. The most recent description of a previously unknown and taxonomically distinct population of West Indian boas was the description of the third subspecies of the Southern Bahamas Boa, the Crooked-Acklins Boa (*C. chrysogaster schwartzi*) from the Crooked-Acklins Bank (Buden, 1975). The last discovery of a new species of West Indian boa was *C. exsul* in 1942 from the Little Bahamas Bank (Netting and Goin, 1944). Here we report the discovery of a new species of Bahamian boa based on an examination of six live individuals found in situ on the Conception Island Bank. We name this new species *Chilabothrus argentum* **sp. nov.**, the Conception Bank Silver Boa (Fig. 1), and characterize it on the basis of morphological and genetic data relative to other members of the genus.

MATERIALS AND METHODS

Study area

The Conception Island Bank (16 km²) is a partially submerged platform independent from other surrounding banks, such as the Great Bahama Bank (Cat and Long islands being adjacent) and the Rum Cay and San Salvador banks (Fig. 2). Presently the bank consists of a main island, Conception Island (area 7.0–9 km², maximum elevation 25 m asl), as well as Booby Cay (area ~0.03 km², maximum elevation 30 m asl) and several small satellite islets (Franz and Buckner, 1998). These islands support a variety of terrestrial habitat types, including coastal *Coccothrinax argentata* scrub, mangrove forest, tropical dry scrub, and mature coppiced tropical dry forest. The terrestrial herpetofauna is generally depauperate relative to the adjacent Great Bahama Bank, with the



Figure 1. The Conception Bank Silver Boa (*Chilabothrus argentum*). Photo by RGR.

Conception Bank supporting only five species relative to 16 on Long Island (Buckner *et al.*, 2012).

Data collection

We visited the Conception Island Bank to conduct herpetofaunal surveys, and upon discovering the first boa set about a systematic survey. We surveyed arboreal and terrestrial habitat for boas using headlamps for 40 person hours 16 and 17 July 2015. We will not disclose exact localities, as we have significant concerns about the potential for damage to this population despite being protected within a national park. We hand captured boas and placed them into a cloth pillowcase for later processing. We measured mass to the nearest gram using a spring scale, and obtained snout–vent length (SVL) and tail length (TL) measurements to the nearest millimeter by extending a string along the dorsal surface of the extended snake. We obtained the following head measurements: head width (widest head width); head length (anterior of the rostral scale to the posterior of the mandible); labial length (posterior-most supralabial scale to the anterior tip of the rostral scale); interocular length (narrowest distance between orbits); ocular length (horizontal diameter of ocular scale); narcs–

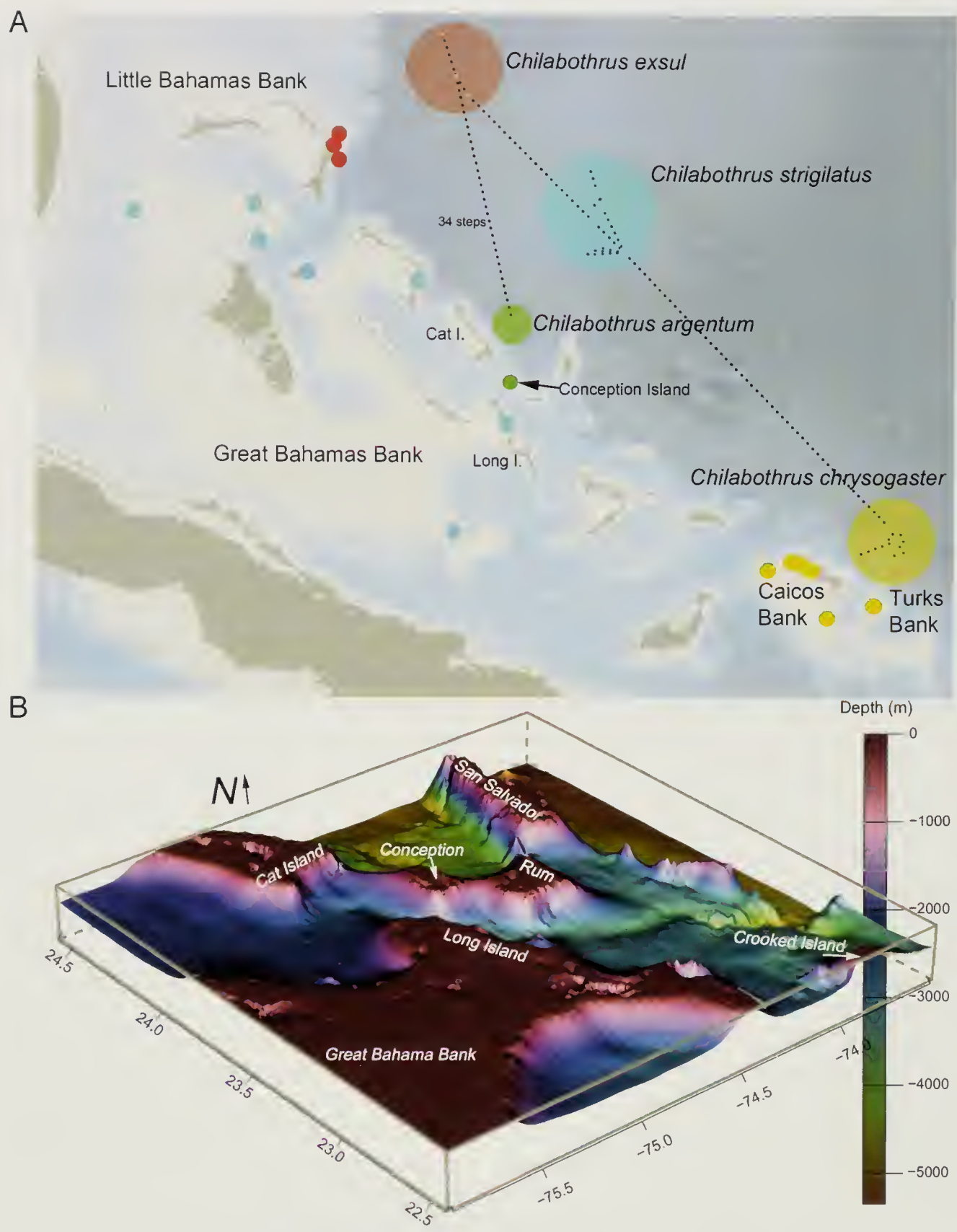


Figure 2. A, Mitochondrial *CYTB* haplotype minimum-spanning network for Bahamian boa species (genus *Chilabothrus*) overlaid onto a map of the region showing major islands (in gray), major island banks (in white), and isobaths representing ocean depth in darkening shades of blue. Geographic locations mentioned in the text are labeled. Solid-colored circles represent sampling locations for each species, whereas large semitransparent circles represent the extent of haplotypes for each species in the network. White dots in the network represent observed haplotypes, whereas black dots represent unsampled haplotypes (mutational steps). B, Bathymetric contour surface

ocular length (anterior edge of ocular to posterior edge of nares); rostral–ocular length (anterior edge of ocular scale to anterior edge of rostral scale); internares length (narrowest internarial distance); and labial–ocular length (posterior edge of posterior supralabial scale to posterior edge of ocular scale). We used dial calipers for all measurements, rounding to the nearest 0.1 mm. We further obtained ventral and subcaudal scale counts, as well as head scalation from digital macrophotographs of all specimens. Finally, we obtained DNA samples, consisting of 3–10-mm tail clips preserved in 95% ethanol. We sanitized tails before and after clipping and applied antiseptic dermal adhesive to prevent infection. We extracted whole genomic DNA using the Promega Wizard SV DNA purification system according to the manufacturer's protocol and stored the extracts at -20°C .

Genetic data and analyses

We used genetic data to contextualize the divergence and phylogenetic relationships of *C. argentum* relative to other West Indian boas. We used the polymerase chain reaction to amplify the mitochondrial (mt)DNA locus cytochrome B (*CYTB*), which has been shown to be useful in species identification in boas (Campbell, 1997; Burbrink, 2004; Reynolds *et al.*, 2013), from six samples of *C. argentum* as well as representatives from each of the other boa species from the Bahamas Archipelago ($n = 6\text{--}24$ per species). We conducted all reactions in a Benchmark Scientific® TC9639 nongradient thermocycler. We purified and sequenced products on an automated sequencer (ABI 3730XL) at Massachusetts General Hospital DNA Core Facility, Cambridge, Massachusetts. We assembled contigs and manually verified ambiguous

base calls using Gencious 7.1.2 (Biomatters, Auckland, New Zealand). We then aligned sequences using the ClustalW 2.1 (Larkin *et al.*, 2007) algorithm implemented in Gencious). We estimated a model of nucleotide substitution (HKY + I + G) using BIC in jModelTest2 (Guindon and Gascuel, 2003; Darriba *et al.*, 2012), and deposited the representative sequence in GenBank (KU179432).

We used the mtDNA *CYTB* locus to examine phylogeographic structuring in Bahamian boas. We inferred haplotypes and connection distances between haplotypes from all four species of boas from the Bahamas Archipelago using a minimum spanning network implemented in Arlequin 3.5.1.3 (Excoffier and Lischer, 2010). We then visualized haplotype connections using HapStar (Teacher and Griffiths, 2010). We calculated pairwise corrected Tamura–Nei genetic distances between Bahamian *Chilabothrus* species using MEGA6 (Tamura *et al.*, 2013). To temporally contextualize divergence of *C. argentum*, we estimated a time-calibrated mitochondrial coalescent tree for all species of West Indian *Chilabothrus*. We estimated a substitution rate for the mtDNA locus from the alignment of West Indian boas by constraining the root node of *Chilabothrus* using a normal prior with a mean of 21.7 million years ago (Mya) and a standard deviation of 1.8 Mya, derived from a fossil-calibrated divergence time analysis of the larger Neotropical boid phylogeny (Reynolds *et al.*, 2013, 2015). We ran the Markov chain Monte Carlo for 100 million generations in the program Beast v1.8 (Drummond *et al.*, 2012) using a Yule speciation prior and an uncorrelated lognormal relaxed clock model. We repeated the analysis three times with different starting parameter values, sampling every 1,000 generations and

←

for the Conception Island Bank relative to other island banks in the central-eastern Bahamas (depths are approximated in the legend).



Figure 3. Six boas found on Conception Island. Photos by ARPR and archived at the Museum of Comparative Zoology as Herpetology Observations 16 through 21.

discarding the first 25% of generations as burn-in, to generate effective sample sizes (ESS) larger than 200 for all parameters. We assessed convergence of the independent runs by a comparison of likelihood scores and model parameter estimates in TRACER v1.5 (Rambaut *et al.*, 2013). We combined results from the three analyses using Logcombiner v1.8, generated a maximum clade credibility

tree using TreeAnnotator v1.8, and publicly accessioned the resulting tree in Treebase (<http://purl.org/phylo/treebase/phylows/study/TB2:S18499>).

Conservation status

To assess the conservation status of *C. argentum*, we used the framework of the



Figure 4. Close-up head views of six boas described in this manuscript. Photos by RGR and ARPR and archived at the Museum of Comparative Zoology as Herpetology Observations 16 through 21.

International Union for the Conservation of Nature (IUCN) Red List Assessment (IUCN, 2015), as has been done for most other Caribbean reptiles. As a component of this assessment, we estimated extent of occurrence (EOO) for *C. argentum* using the GeoCAT online tool (Bachman *et al.*, 2011).

RESULTS

In July 2015 we found a total of six boas on the Conception Island Bank, five females and one male (Figs. 1, 3–5). All boas were active and apparently foraging. Boa one (female) was found 1 m high in a ~2-m-tall silver palm (*Cocothrinax argentata*). Boas two



Figure 5. Male *Chilabothrus argentum* displaying agile climbing behavior. Photo by RGR.

and three (both females) were found together in a 3-m-high bush (genus unknown). Boa four (female) was found crawling on the ground at the base of a *Bursera simaruba* tree. Boa five

(male) was found 3 m high on a horizontal branch (~15-cm diameter) of a *B. simaruba* tree (Fig. 5). This boa used a single-coil grip to anchor the tail and trunk while extending the body to move between limbs. Boa six (female) was found indirectly, as it crawled onto the first author’s head at 0337 h as he slept on the beach next to the forest. We returned to Conception Island Bank in October 2015 to obtain a holotype specimen (Fig. 6) and a single paratype specimen (Fig. 7).

All boas exhibited a greatly reduced color pattern relative to other Bahamian species, which are generally characterized by large dark blotches or stripes (Fig. 8). The dorsal ground color is silver gray to very light tan, occasionally with a very faint gray dorsal stripe extending the length of the spine with jagged edges and occasional interruption (Fig. 3). A few scales are darker gray to brown, scattered across the dorsum either singly or in clusters of three to eight. The venter is pure cream white with no markings or other coloration. Boas averaged 952.5 mm SVL (range 876–1029) and 196.6-mm TL (range 184–209), with the largest individual being a male (Fig. 5; Table 1). We found a mean of 277.6 ventral scales (range 275–282), a mean of 87.3 subcaudal scales (range 82–91), and

TABLE 1. MORPHOMETRIC DATA OBTAINED FROM CONCEPTION BANK SILVER BOAS (*CHILABOTHIRUS ARGENTUM*). ALL LINEAR MEASUREMENTS ARE IN MILLIMETERS. SVL, SNOUT–VENT LENGTH; HL, HEAD LENGTH; HW, HEAD WIDTH; LL, LABIAL LENGTH; IO, INTEROCULAR DISTANCE; RO, ROSTRAL–OCULAR LENGTH; NO, NARES–OCULAR LENGTH; IN, INTERNARES DISTANCE; LO, LABIAL–OCULAR LENGTH.

	Sex	SVL	Tail	HL	HW	LL	IO	OL	RO	NO	IN	LO	Mass (g)	Ventrals	Subcaudals
argentum 1	F	927	197	32.1	13.6	26.2	11.9	3.4	12.1	9.5	4.8	10.8	198	278	90
argentum 2	F	876	184	30.5	16.4	26.4	11.0	3.5	11.1	8.8	4.5	9.1	182	282	91
argentum 3	F	978	197	33.6	17.8	30.1	11.7	3.5	13.2	10.2	5.0	12.0	241	277	89
argentum 4	F	889	190	31.5	17.7	27.8	11.5	3.4	12.5	10.0	4.6	11.1	230	275	90
argentum 5	M	1,029	203*	34.0	16.9	27.2	12.6	3.9	13.2	10.8	5.3	11.6	258	278	82
argentum 6	F	991	209	32.5	19.2	26.8	11.9	4.1	12.5	10.0	5.1	11.5	238	275	91
Holotype	F	952	190	32.1	16.4	28	12	3.4	9.8	12	4.6	11.1	240	278	83
Paratype	M	978	209	32.5	16.5	28.2	12.5	3.8	10.2	12.8	4.5	12.1	230	278	82

*Tail damage observed.

TABLE 2. SCALE COUNT AND MORPHOLOGICAL COMPARISONS AMONG THE FOUR *CHILABOTHIRUS* SPECIES FROM THE BAHAMAS PLATFORM. DATA ARE FROM SHEPLAN AND SCHWARTZ (1974), BUDEN (1975), TOLSON AND HENDERSON (1993), AND THIS STUDY. SQUAMATION IS REPORTED AS RANGES, WITH MEAN IN PARENTHESES. *CHILABOTHIRUS STRIGILATUS* EXHIBITS CONSIDERABLE VARIATION IN COLORATION AND SQUAMATION; WE REPORT HERE TYPICAL CHARACTERISTICS. SVL, SNOUT-VENT LENGTH.

	<i>C. argentum</i>	<i>C. chrysogaster</i>	<i>C. exsul</i>	<i>C. strigilatus</i>
Ventrals	275–282 (mean 277.6)	242–277	236–251	266–295
Subcaudals	82–91 (mean 87.3)	74–95	69–75	76–102
Loreals	1	1–3	1	1
Circumorbitals	6–8	9–13	10	10–11
Supralabials	11–14	12–16	13	14–15
Dorsal blotches	none	light gray to dark brown	light gray to dark brown	light gray to black
Spot/stripe polymorphism	no	yes (Caicos Bank)	no	no
Ventral color	pure cream	pure cream	pure cream	cream to gray to brown, frequent blotches or mottling
Max. female SVL (mm)	991	1,321	810	2,055
Max. male SVL (mm)	1,029	812	unknown	2,330
Sexual size Dimorphism?	no	yes	unknown	unknown

a single loreal scale on all individuals. Other measurements are reported in Tables 1 and 2.

We recovered a single (1,083 base pairs) mtDNA haplotype among the six samples of *Chilabothrus argentum*. Our genetic analyses demonstrate that *C. argentum* is a phylogenet-

ically distinct lineage from other West Indian species, and is sister to other Bahamian boas (Figs. 2, 9). For the mtDNA locus *CYTB*, we found a minimum of 3.3% divergence from other Bahamian boas (range 3.3–5.4%, Table 3) and an estimated coalescent time of



Figure 6. Photos of the paratype (MCZ R-193527) of *Chilabothrus argentum* from the Conception Island Bank. Photos by ARPR.



Figure 7. Photos of the paratype (MCZ R-193528) of *Chilabothrus argentum* from the Conception Island Bank. Photos by ARPR.

2.7 million years (95% highest posterior density interval 1.77–3.89). Tree topology and divergence-time estimates for other nodes in the tree were congruent with previously published analyses (Reynolds *et al.*, 2013, 2015).

We estimated an EOO of < 13.5 km² for *C. argentum*, which, combined with perceived threats to the species, satisfies criteria B1 (a,b) for IUCN Red Listing as critically endangered. We suspect that the species would also qualify under criteria A1 (b,c,d), on the basis of our surveys of potential habitat on the Conception Island Bank; however, much more information is needed to assess under additional criteria. During our surveys we documented the presence

of feral cats on the Conception Island Bank, an alarming discovery given the importance of these islands to nesting and migratory birds as well as to this new species of boa.

DISCUSSION

This study represents the first new in situ discovery of a West Indian Boa species in 73 years (Netting and Goin, 1942). It has been at least 58 years since the in situ discovery of new populations of taxonomically distinct boas in the region, the last being the report in 1957 of boas on Margaret Cay, Ragged Islands, Bahamas (*C. strigilatus mccraniei*; Sheplan and Schwartz, 1974). Recent species descriptions in this group



Figure 8. Other Bahamian species of *Chilabothrus* boas. A, *C. chrysogaster* (striped morph), Big Ambergris Cay, Turks and Caicos Islands. B, *C. strigilatus*, New Providence Island, Bahamas. C, *C. exsul*, Great Abaco Island, Bahamas. All photos by RGR.

TABLE 3. MINIMUM CORRECTED TAMURA–NEI PAIRWISE DIVERGENCE IN MITCHONDRIAL DNA *CYTB* AMONG BOA SPECIES (GENUS *CHILABOTHIRUS*) IN THE BAHAMAS ARCHIPELAGO.

	<i>argentum</i>	<i>chrysogaster</i>	<i>exsul</i>	<i>strigilatus</i>
<i>argentum</i>	—	0.054	0.033	0.041
<i>chrysogaster</i>	—	—	0.059	0.063
<i>exsul</i>	—	—	—	0.033
<i>strigilatus</i>	—	—	—	—

(e.g., *C. granti*; Rodriguez-Robles *et al.*, 2015) constitute elevations of cryptic species on the basis of genetic data. Subspecies in this group were largely described on the basis of known populations to accommodate significant differences observed in coloration and squamation (e.g., Sheplan and Schwartz, 1974; Buden, 1975).

It is worthwhile to note that a snake fitting the description of a boid was reported from the Conception Island Bank by R. A. Ober and the crew of the yacht *SNAFU* in the mid-1970s (Schwartz *et al.*, 1978; Franz and Buckner, 1998). The crew apparently removed a specimen from the island, but all material from the *SNAFU* expedition was subsequently lost (as far as we know, for unknown reasons) before being examined by additional researchers. It was hypothesized by Schwartz *et al.* (1978), on the basis of notes from R. A. Ober, that if boas did exist on the Conception Island Bank, they likely belong to the species *C. strigilatus* from the nearby Great Bahama Bank (25 km WSW). Subsequently, *C. strigilatus* was authoritatively listed as occurring on the Conception Island Bank in Buckner *et al.* (2012), despite the lack of a specimen, photograph, or reliable record. As we show here, boas do indeed occur on the Conception Island Bank, though they represent a new species that is phylogenetically sister to the *C. exsul*/*C. striatus*/*C. strigilatus* clade, and not a subpopulation of the geographically proximate *C. strigilatus*.

Biogeography

A plausible explanation for which boas arrived at the Conception Island Bank is the direction of currents and hurricane sets in the region, being generally northwesterly from Hispaniola (Hedges, 2001, 2006). This would provide the appropriate conditions for the dispersal of boas from Hispaniola to the southern Bahamas banks—from the recently submerged Silver, Navidad, and Mouchoir banks to the presently emergent banks of the southern Bahamas Archipelago. Boas could then disperse from these banks in the same direction toward both Rum Cay and Conception Island. Curiously, no boas have ever been reported from Rum Cay. We conducted diurnal and nocturnal herpetofaunal surveys in different habitats on Rum Cay between 10 and 13 July 2015, and found no evidence of boas. We also interviewed residents of this island regarding their memories of or encounters with snakes, and no resident reported ever having seen a snake on Rum Cay. The island has a long history of human habitation, including salt production in the mid-19th century (Sealey, 2006). Columbus reported a large population of native peoples on Rum Cay in October of 1492 (Morrison, 1942), and archeological evidence suggests an initial colonization of this area roughly 800–1000 AD (Sears and Sullivan, 1978; Berman and Gnivecki, 1995). Hence, it is possible that boas once occurred on Rum Cay and have since gone extinct. As the Conception Island Bank is in the ocean current and hurricane “shadow” of Rum Cay, it seems unlikely that boas historically colonized the Conception Island Bank and not the Rum Cay Bank. *Chilabothrus argentum* could have been more widespread in the past and might have since shrunk in range.

Species diversity in the Bahamas appears to be determined by a combination of both dispersal from larger landmasses as pre-

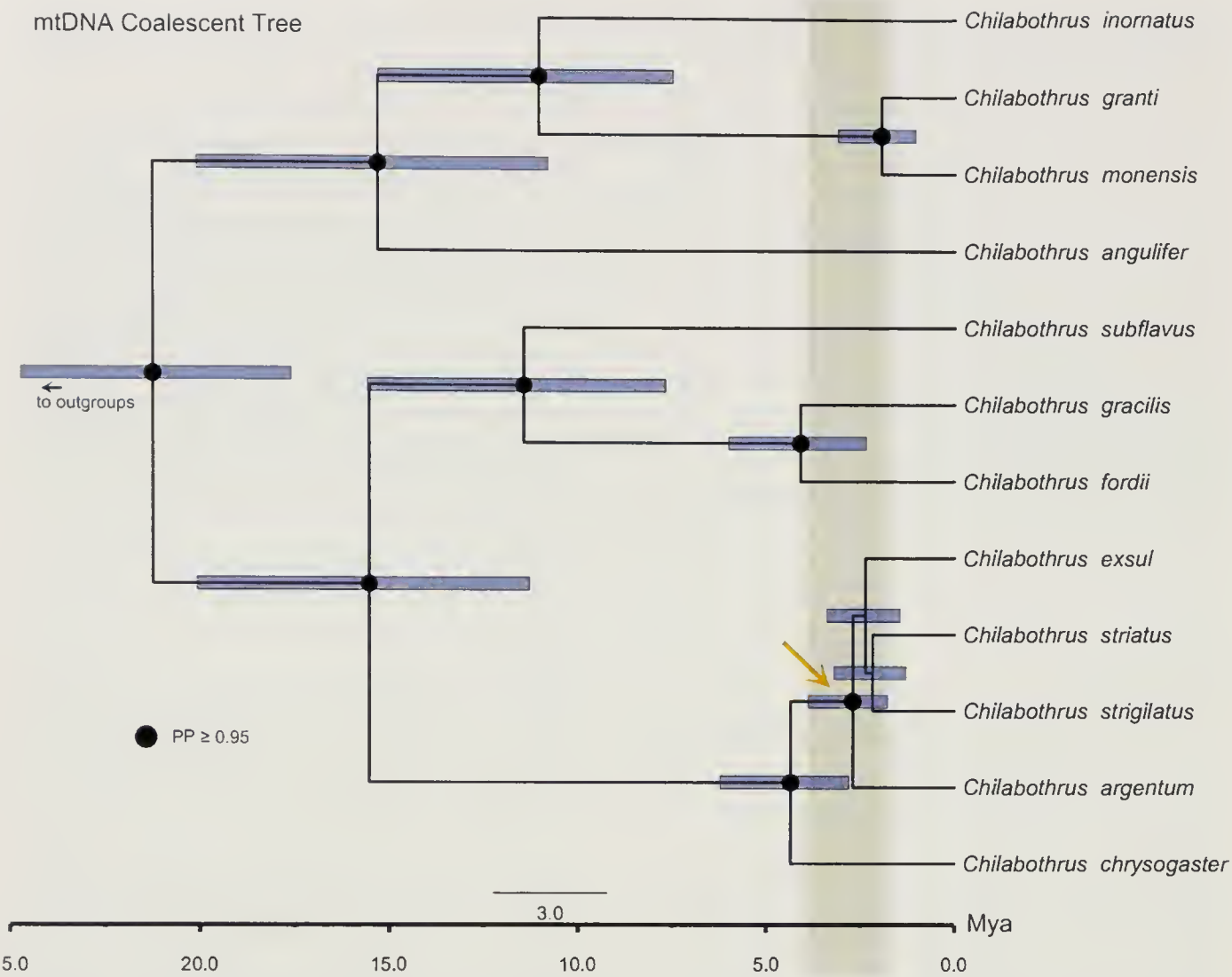


Figure 9. Time-calibrated phylogenetic coalescent tree for the mitochondrial locus *CYTB* for species of West Indian *Chilabothrus*. 95% highest posterior density (HPD) intervals are shown as nodal bars, whereas black circles at nodes indicate posterior probabilities (PP) ≥ 0.95. A vertical gray bar spans the 95% HPD interval for the split of the new species *C. argentum*, which is indicated by an orange arrow. Refer to Table 4 for additional nodal information.

dicted by the theory of island biogeography (MacArthur and Wilson, 1967) and in situ diversification. Some lineages seem to be clear instances of dispersal to the Bahamas from larger landmasses, such as dispersal of Brown Nuthatch (*Sitta pusilla*) from North America to the Bahamas ~700,000 years ago (Lloyd *et al.*, 2008). Other studies find that the small size of Bahamian islands does not preclude in situ divergence. Deep population structure exists within populations of the Bahamian Parrot, *Amazona leucocephala bahamensis* (Russello *et al.*, 2010). Very recent (6,000–

10,000 years ago) speciation has been shown in cyprinodon pupfishes in San Salvador lakes (Martin and Wainwright, 2013), and incipient speciation of Andros mosquitofish is thought to have been initiated within the last 15,000 years (Langerhans *et al.*, 2007). We estimated a mitochondrial coalescent time of 2.7 million years on the basis of a standard molecular clock for the West Indian boas, though we note that a single-locus coalescent time will naturally predate an actual divergence time (Degnan and Rosenberg, 2009). Most geologic estimates place the formation

TABLE 4. POSTERIOR PROBABILITIES AND DIVERGENCE TIMES FOR THE MITOCHONDRIAL GENE TREE FOR WEST INDIAN BOAS (*CHILABOTHIRUS*). THE NODE SEPARATING THE NEW SPECIES *C. ARGENTUM* IS IN BOLD. HPD, HIGHEST POSTERIOR DENSITY INTERVAL.

Node	Posterior Probability	Divergence Time (Mean)	95% HPD
1	1.00	21.26	17.61, 24.73
2	0.98	15.54	11.29, 20.09
3	0.99	15.31	10.80, 20.10
4	0.97	11.44	7.68, 15.58
5	0.98	11.05	7.48, 15.30
6	1.00	4.36	2.81, 6.23
7	1.00	4.09	2.35, 6.00
8	1.00	2.70	1.77, 3.89
9	0.43	2.37	1.44, 3.39
10	0.40	2.17	1.29, 3.20
11	1.00	1.95	1.04, 3.10

of the presently emergent Bahamas in the Pleistocene (Sealy, 2006). Boas join a list of other taxa that suggest that divergence of Bahamian species might predate this estimate. The lizard *Ameiva maynardi* diverged from Hispaniolan populations of *A. lineolata* 2–5 Mya (Hower and Hedges, 2003). Recent evidence suggests that in situ divergence between Bahamian subspecies *A. distichus distichus* and *A. d. ocior* occurred 2.3–6.6 Mya (Geneva *et al.*, 2015). Skinks in the genus *Spondylurus* likely colonized the Bahamas banks in the late Pliocene/early Pleistocene (Hedges and Conn, 2012). Estimates of divergence times for other Bahamian *Chilabothrus* species suggest that the initial colonization of the southern Bahamas occurred in the late Pliocene (Reynolds *et al.*, 2013), and *C. argentum* further supports multiple colonization from Hispaniola during the Pleistocene.

Behavior

Of further interest is the apparently arboreal habitat preference and adept climbing ability of *C. argentum*. Boas in the

Bahamas are either largely or exclusively terrestrial (*C. chrysogaster* and *C. exsul*) or substrate generalists (*C. strigilatus*), utilizing arboreal, terrestrial, and even subterranean habitats (Tolson and Henderson, 1993; Henderson and Powell, 2009). Though we encountered one boa on the ground, the other five individuals were found in arboreal situations and exhibited characteristic climbing abilities and behaviors, such as concertina locomotion along large-diameter horizontal limbs. Such behaviors and abilities are noteworthy, as some forms of locomotion such as concertina are known to be highly energetically expensive (Walton *et al.*, 1990).

Conservation

All islands on the Conception Island Bank are currently designated as Bahamas National Park and are managed by the Bahamas National Trust. These islands represent a regionally significant habitat for a variety of terrestrial and marine animals, including nesting seabirds, juvenile fishes, and sea turtles. Visitors to the islands are relatively rare, and mostly consist of transiting sailboats that anchor leeward of Conception Island and whose sailors frequently come ashore to walk around the exterior of the island (often accompanied by their dogs) or explore the inner lagoon by dinghy. Other visitors are day or overnight dive and fishing boats from Long and Cat islands. Despite the protection afforded by its remote location, lack of human inhabitants, and protection as a national park, we have significant concerns about the well-being of this new boa. On the basis of an EOO of < 13.5 km² and overall Red List assessment, we find that *C. argentum* should be listed as critically endangered from criteria B1(a,b), and hence *C. argentum* is one of the most endangered boid snakes globally. Our discovery of feral cats on the

bank is of significant concern, as *Chilabothrus* are highly vulnerable to predation by cats (Grant, 1940; Tolson and Henderson, 1993). Boas in the genus *Chilabothrus* are highly sought after in the pet trade and can occasionally command thousands of U.S. dollars per individual. Boas are frequently poached for the pet trade throughout the Caribbean (Dodd, 1986) and we are extremely concerned that the discovery of a new boa could elicit poaching activity. Indeed, Green Sea Turtles (*Chelonia mydas*) are occasionally poached from the interior lagoon of Conception Island (Bjorndal *et al.*, 2003; Knapp *et al.*, 2011). We report this new boa in the interest of scientific knowledge, yet we intentionally refrain from describing exact localities or habitats for this reason. We also call for a restatement of the importance of protecting the Conception Island Bank for the good of the Bahamian wildlife and Commonwealth.

Conclusions

Netting and Goin (1944) prophesized that more boid species might be found in the Bahamas. Nearly 71 years hence, we report the discovery of a new boa from the Conception Island Bank, Bahamas. We name this new species *C. argentum* **sp. nov.**, the Conception Bank Silver Boa, and consider it a novel species on the basis of its unique appearance, color pattern, arboreal habits, phylogenetic uniqueness, and geographic isolation. We expect that ongoing studies of this new boa will contribute to continuing biogeographical and phylogenetic reconstructions of the ecology and evolution of this unique group of West Indian boas. We further recommend that strict and immediate conservation measures be enacted to protect these boas from introduced feral cats and human disturbance.

Taxonomy

Chilabothrus argentum, **sp. nov.**

Conception Bank Silver Boa

Figures 1, 3–7

ZooBank registration: urn:lsid:zoobank.org:act:A08E93B6-798E-4596-A669-CF1FC3F8-D1A3

Holotype. MCZ R-193527. An adult female obtained 21 October 2015. Found at night climbing 1.5 m high in a *B. simaruba* tree. Specimen measurements are listed in Table 1. Specimen squamation on the right side is as follows: 278 ventrals, 83 subcaudals, 14 supralabials, 1 loreal, 1 preocular, 1 suborbital, 4 postoculars, and 2 supraoculars.

Paratype. MCZ R-193528. An adult male, obtained 21 October 2015. Found at night moving horizontally 2 m high on a *B. simaruba* branch. Specimen measurements are listed in Table 1. Specimen squamation on the right side is as follows: 278 ventrals, 83 subcaudals, 13 supralabials, 1 loreal, 1 preocular, 1 suborbital, 4 postoculars, and 1 supraocular. Preocular and sixth supralabial scales on the left side of the head are malformed, as is the fifth supralabial on the right side of the head.

Additional Specimens. Additional specimens are a series of photographs from six individuals (five females and one male) accessioned into the MCZ Herpetology Observations Collection (MCZ accession #s Herpetology Observations 16–21) taken on 16 July 2015 by ARPR and RGR.

Distribution. Known only from the Conception Island Bank, Bahamas.

Definition. A species of *Chilabothrus* boid snake possessing the following characteristics: silver to tan dorsal background coloration with or without scattered dark brown scales, which appear either individually or in small clusters; a reduced to absent dorsal pattern consisting of faint light-gray elongate dorso-ventral blotching, occasionally no pattern is

obvious; pure cream-white ventral scales; a single loreal scale; ventral scale count ranging from 275 to 282; subcaudal scale count ranging from 82 to 91; a low number (11–12) of supralabials; 9–10 circumorbitals; largely arboreal substrate use; phylogenetic distinctiveness at mitochondrial locus *CYTB* consisting of > 3% pairwise divergence from other Bahamian *Chilabothrus* species.

Three other species of boas are known from the Bahamas (Fig. 8). The Northern Bahamas Boa (*C. exsul*) was described by Netting and Goin (1994) on the basis of a specimen obtained by A. Twomey of the Carnegie Museum in 1942. This was the most recent in situ discovery of a new species of boa in the West Indies, though its existence was apparently not terribly surprising. Thomas Barbour prophetically wrote “I do not know whether there is a fowl snake to be found on the Abacos or Grand Bahama. If so, it is not unlikely that this will prove to be another undescribed form” (1941; as quoted in Netting and Goin, 1944). *Chilabothrus exsul* is characterized by a light gray to tan background color, usually with very bold dark gray to black dorsal blotches (Fig. 8). Meristic characters are quite different from *C. argentum* (Table 2), with a much lower number of ventral and subcaudals and a higher number of supralabials. Body size is also considerably smaller—*C. exsul* has the shortest SVL of the (now) 12 *Chilabothrus* species and is nearly exclusively terrestrial, occupying crevices in karst formations or being found under cover objects. Phylogenetically, *C. exsul* is sister to the *C. striatus*/*C. strigilatus* subclade (Fig. 9), though the node subtending the *exsul*/*striatus*/*strigilatus* clade has been consistently recovered as a polytomy in recent reconstructions of the *Chilabothrus* clade (Reynolds *et al.*, 2013, 2014, 2015). Hence the exact relationships among *C. exsul*, *C. striatus*, and *C. strigilatus* remain unclear, though current study using genomic

single-nucleotide polymorphism genotyping is aiming to resolve these relationships (R. G. Reynolds, unpublished data). Nonetheless, these three species are vastly different in behavior, ecology, body size, coloration, and other characteristics (Tolson and Henderson, 1993). We recovered strong support for an earlier divergence of *C. argentum* **sp. nov.** from the *exsul*/*striatus*/*strigilatus* clade, supporting the uniqueness of this lineage relative to other nearby Bahamian boas and a possibly additional colonization of the Bahamas from Hispaniola.

The Bahamas Boa (*C. strigilatus*, Fig. 8) was originally described as *Homalochilus strigilatus* from New Providence, Bahamas by Cope (1862; given as 1863 in many references) and later listed as from “Andros island (sic), Bahamas” in Garman (1887). Cope distinguished it from *C. striatus* by the presence of minor meristic and coloration differences, which we now know to be quite variable in these species (R. G. Reynolds, personal observation). Nevertheless, Reynolds *et al.* (2013) separated the species from synonymy with *C. striatus* owing to phylogenetic and morphological uniqueness. *Chilabothrus strigilatus* is a very large species, attaining a maximum SVL exceeding 2 m, and is a habitat and dietary generalist (Tolson and Henderson, 1993). Although differences in body size, squamation, and coloration exist among islands and among the five subspecies (Tolson and Henderson, 1993), this species is generally heavily patterned, large bodied, and easily distinguishable from *C. argentum* **sp. nov.** (Fig. 8). Ventral and subcaudal scale counts are similar in range, as are other meristic characters we quantified except for supralabials, which are generally more numerous in *C. strigilatus*. Phylogenetically, *C. strigilatus* appears to be sister to *C. striatus* from Hispaniola and is recently derived from that species. This is consistent with a recent

colonization from Hispaniola (Reynolds *et al.*, 2013) similar to other Great Bahama Bank species.

The Southern Bahamas Boa (*C. chrysogaster*, Fig. 8), is a complex of three subspecies occurring on the Turks, Caicos, Inagua, and Crooked-Acklins banks in the southern Bahamian Archipelago. A detailed review of the taxonomy and taxonomic history is provided in Reynolds (2012). The type specimen was described by Cope (1871) from “Turks Island,” which was presumed to be referencing Grand Turk on the Turks Bank (Buden, 1975; Reynolds, 2012). South Caicos was also referred to as “Turks Island” in the 19th century, and hence the original holotype (ANSP 10322, specimen is lost) could have actually come from the Caicos Bank. Boas were not recorded since on the Turks Bank until the description (Reynolds and Niemiller, 2010) and genetic characterization (Reynolds *et al.*, 2011) of a previously unknown Turks Bank population on Gibbs Cay (Reynolds, 2011). *Chilabothrus chrysogaster* was subsequently reorganized into two subspecies in Sheplan and Schwartz (1974) to include the Turks Island Boa (*C. chrysogaster chrysogaster*) on the Turks and Caicos banks; as well as the Inagua Boa (*C. chrysogaster relicquus*). Buden (1975) described a third subspecies (*C. chrysogaster schwartzi*) from the Crooked-Acklins Bank. *Chilabothrus argentum* **sp. nov.** is similar in scale counts to *C. chrysogaster*, particularly to *C. c. schwartzi*, though *C. chrysogaster* generally has fewer ventrals (242–277 versus 275–282 in *C. argentum*) and more supralabials (12–16 versus 11–12 in *C. argentum*) and is quite variable in meristic characters and coloration across its range (Tolson and Henderson, 1993; Reynolds and Gerber, 2012). *Chilabothrus c. relicquus* is variable in coloration (Suppl. Fig. S1), and most specimens have some dorsal patterning and resemble other members of the species.

Occasionally individuals of *C. chrysogaster* have reduced color patterns (Reynolds and Gerber, 2012), and one specimen of *C. c. relicquus* (KUH 260080; Suppl. Fig. S1) has a color pattern somewhat similar to *C. argentum* **sp. nov.**, though this specimen has two loreals (like *C. chrysogaster*) and a higher number of supralabials (13 versus 11–12), preoculars (3 versus 1), and postoculars (5 versus 4), all similar to *C. chrysogaster*. *Chilabothrus argentum* **sp. nov.** does not appear to be phylogenetically similar to *C. chrysogaster*, as the latter apparently split from the rest of the Bahamas boa lineage in the late Pliocene/early Pleistocene (Reynolds *et al.*, 2013, 2015, this study).

Ecology. This species is apparently largely arboreal, and has been found in *Cocothrinax argentata* and *B. simaruba*. Nothing else is known of its ecology or natural history.

Conservation. We have assessed this species as being critically endangered on the basis of IUCN Red List criteria B1 (a,b).

Reproduction. No reproductive information is available.

Etymology. The species name, *argentum*, is the nominative Latin word for silver, referencing the silver coloration of the first specimen encountered in July 2015 as well as its location in a silver palm (*Cocothrinax argentata*) when encountered.

Remarks. The possible existence of boas on Conception Island was first reported in the literature by Schwartz *et al.* (1978) on the basis of an anecdotal account from the crew of the *SNAFU*, which apparently secured a specimen that was subsequently lost. Schwartz *et al.* (1978) considered this boa to belong to *Chilabothrus strigilatus* (prev. *Epicrates striatus*; Reynolds *et al.*, 2013), and possibly to a unique population on the basis of the reduced coloration reported by the collectors (Schwartz *et al.*, 1978; Franz and Buckner, 1998).

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

ACKNOWLEDGMENTS

We are appreciative of support for fieldwork on the Conception Island Bank provided through a Putnam Expedition Grant to RGR as well as funding from the MCZ Thomas Barbour Fund. We thank the Bahamas Department of Agriculture, the Bahamas Environment, Science and Technology Commission, Ministry of the Environment, and the Bahamas National Trust for research and export permits (CITES-2015/196). We thank Shelley Cant and Joseph Burgess for dedicated fieldwork, and are appreciative of the support provided by Eric Carey, Lynn Gape, and the Bahamas National Trust. We thank Sandra Buckner for discussions related to this work and for advice on working on the Conception Island Bank. We thank Kristin Winchell for R code for bathymetric scaling and Luke Mahler and Liam Revell for advice related to this work. We are especially grateful to Jonathan Losos and James Hanken for support, advice, and encouragement. We dedicate this discovery to the people of the Commonwealth of the Bahamas and to the future generations of scientists who will hopefully have the opportunity to study the species in the wild.

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